Constellation-X: The IMBH Machine

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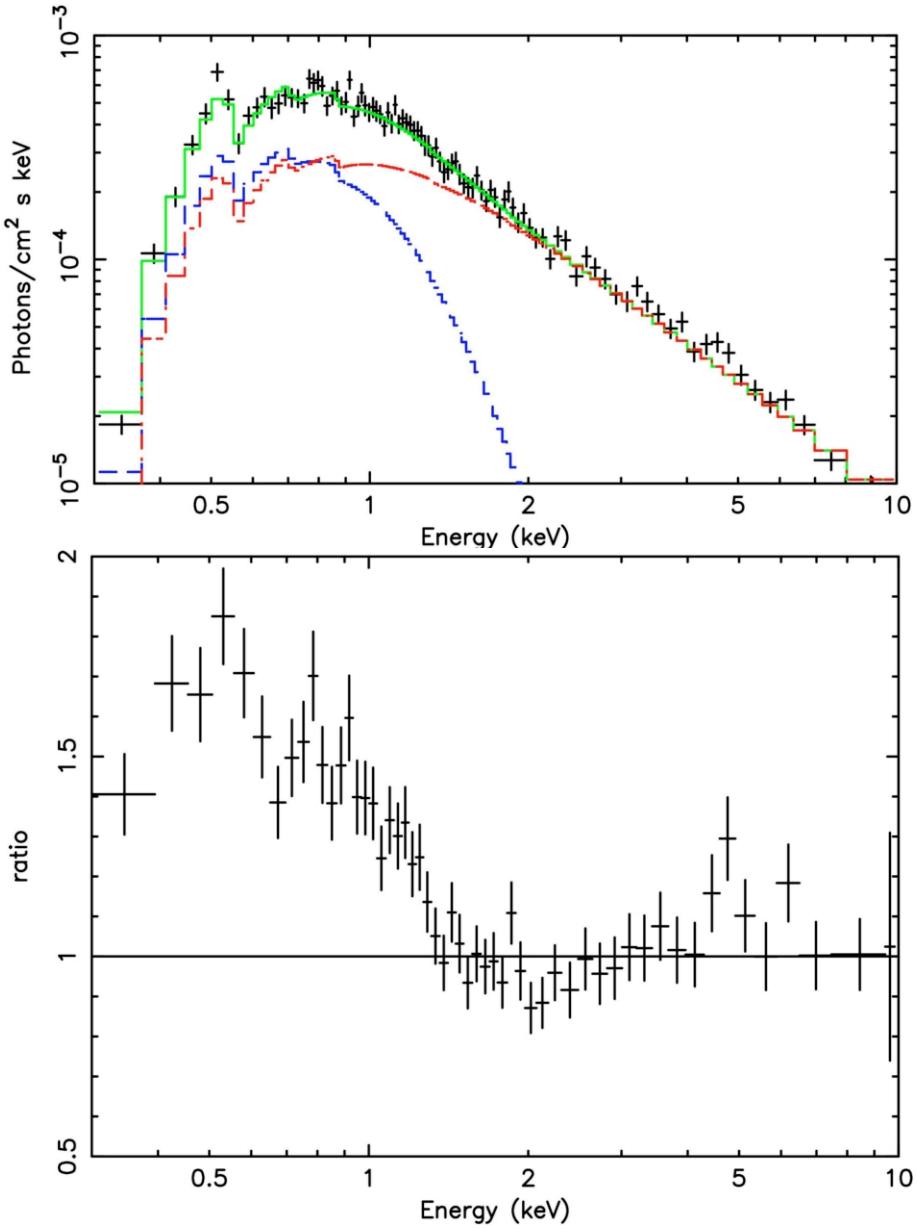
- Evidence for IMBHs in some ULXs is steadily mounting. But far better evidence is needed.

- It will be *very* hard to make radial velocity curves to determine the masses of ULXs:
  - Sources do not seem to turn “off” ◊ disk >> companion.
  - Some sources seem to be embedded in nebulae.
  - Periods may be very long (months?).
  - Fields can be very crowded ◊ spectra contaminated.

- *A preponderance of overwhelming X-ray evidence will likely be decisive for IMBHs … Con-X can do this.*

Cool disks ◊ Evidence for IMBHs



Case Study: NGC 1313 X-1

L_X = 1-2 E+40 erg/s

Edd. Scaling: 100-200 Msun

kT = 0.15 keV

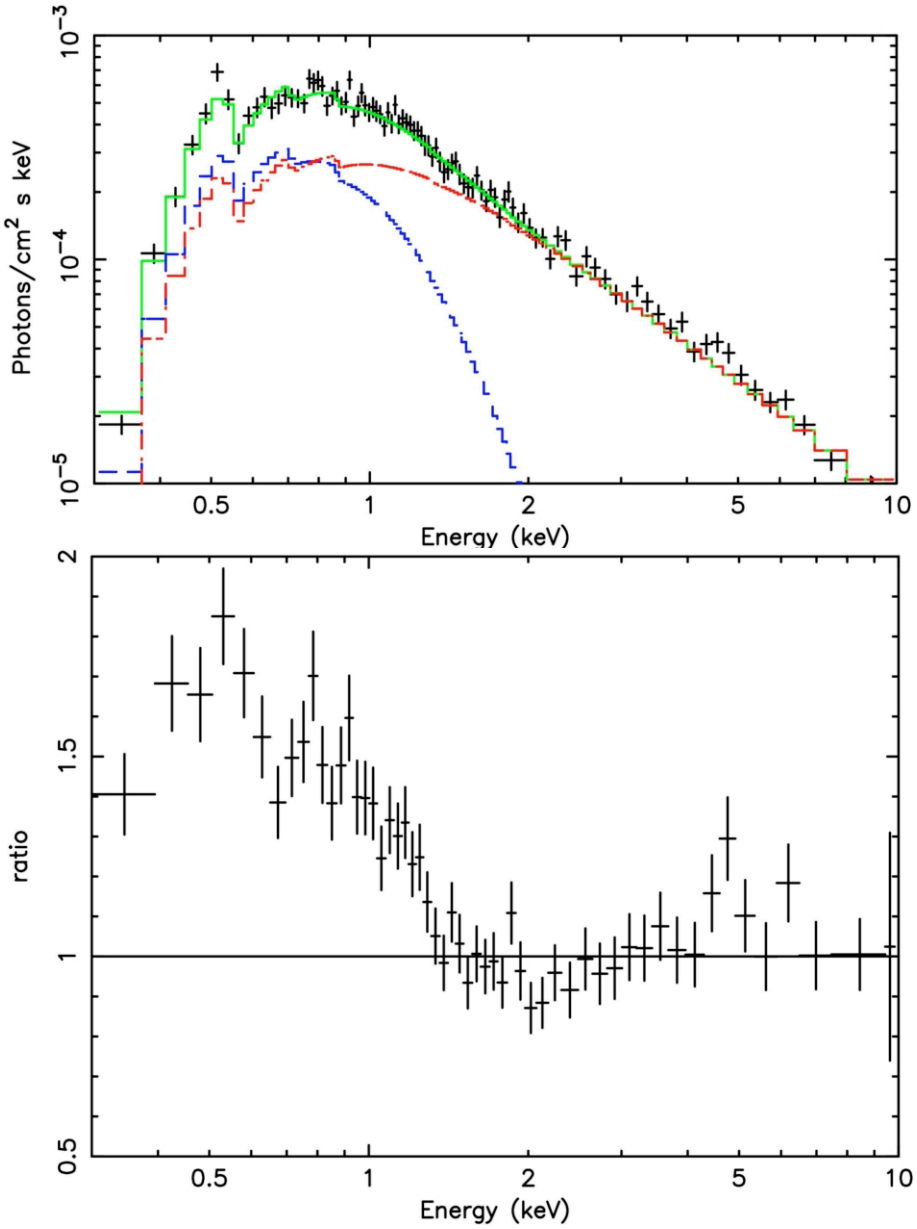
(1 keV typical for 10 Msun)

M = 4000 Msun

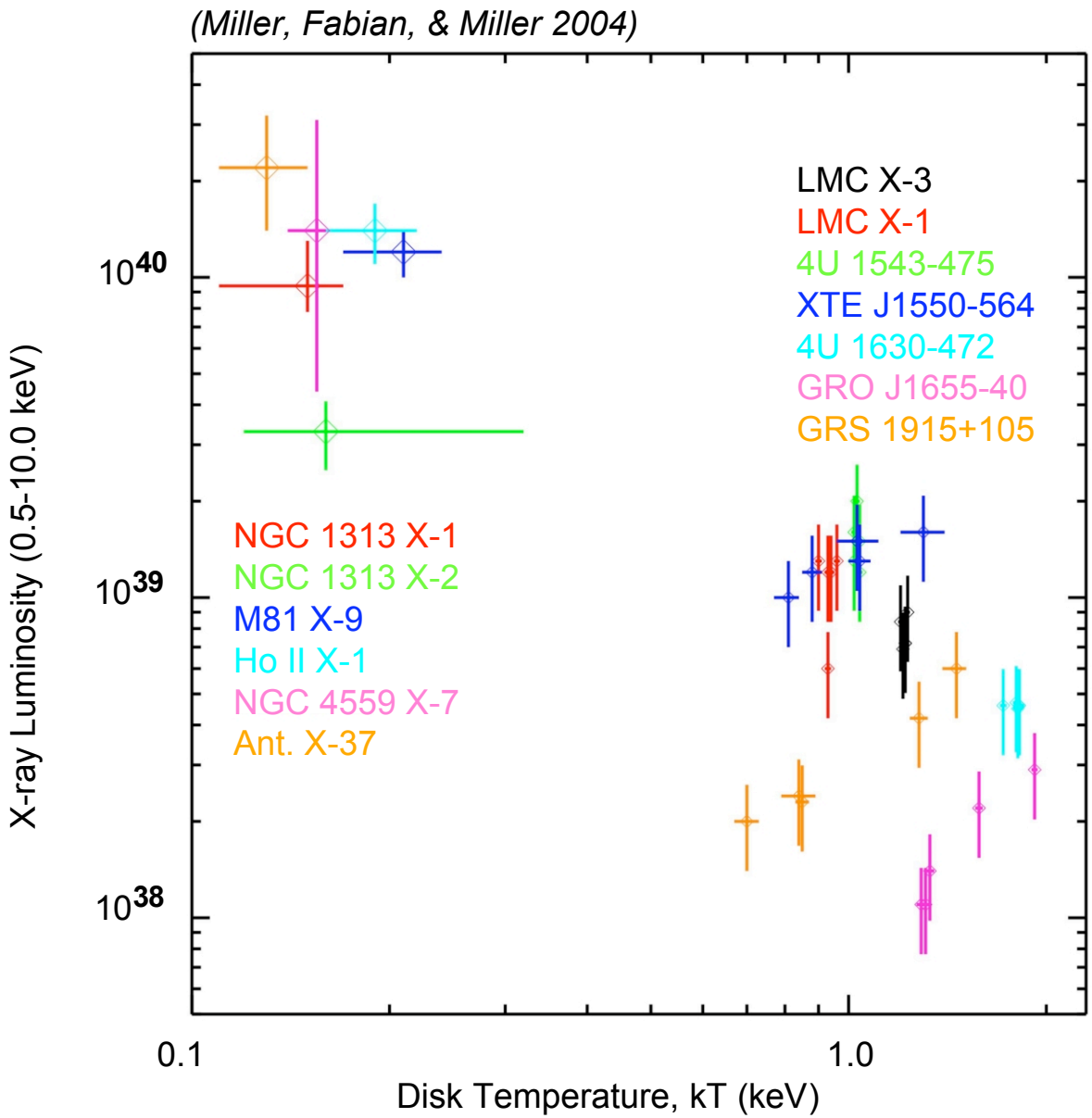
Normalization of the disk:

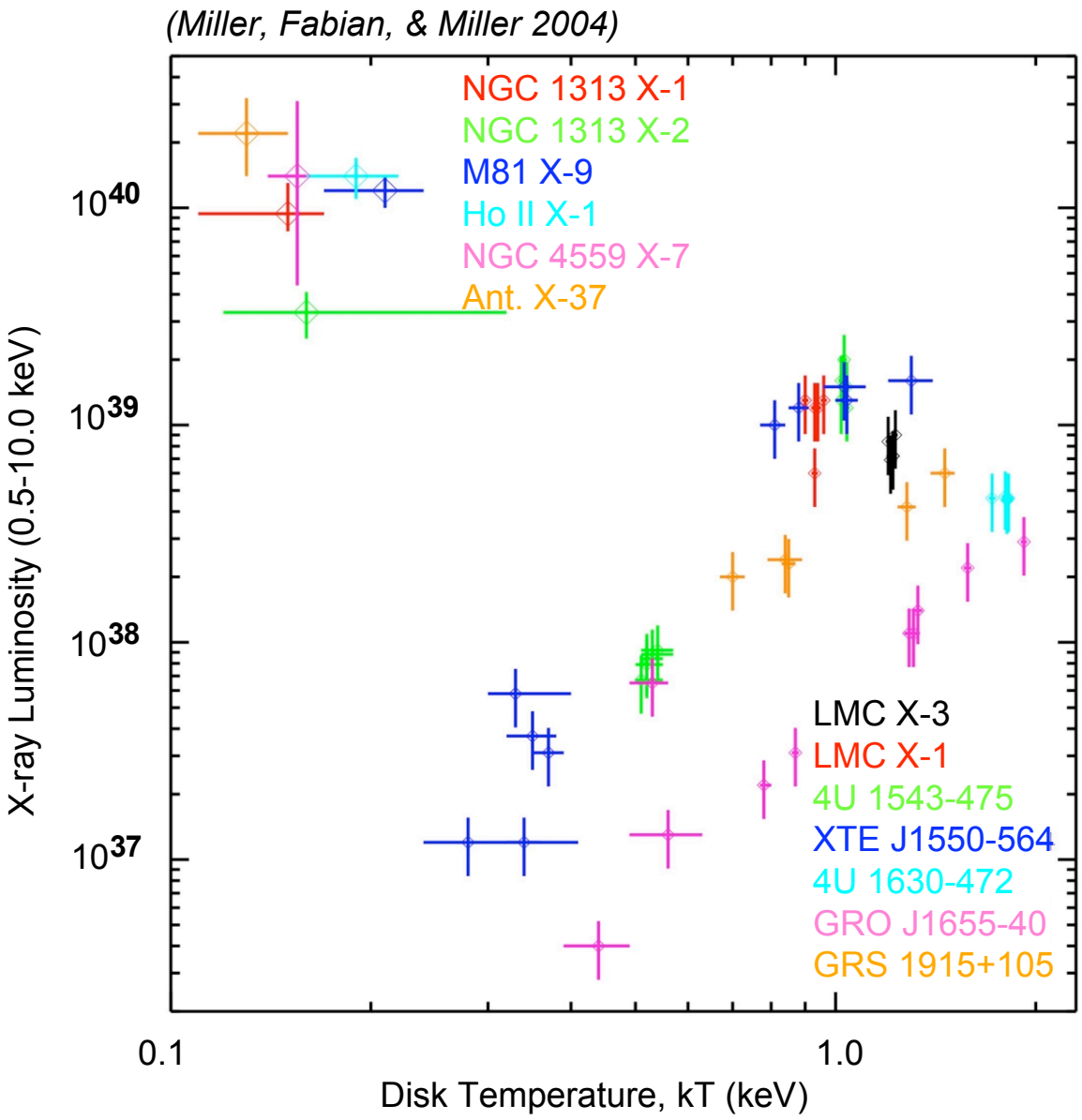
M = 400 Msun

Cool disks ◊ Evidence for IMBHs



- Not an effect of low A_Z in intervening absorption.
- Soft component is indeed a disk, not a photosphere.
- Radio/X-ray flux ratios rule-out relativistic beaming.
- Funneling unlikely.
- “alternative” spectra fail.


(Miller, Fabian, & Miller 2004)
X-ray Luminosity (0.5-10.0 keV)
10^40
10^39
10^38
0.1
1.0
Disk Temperature, kT (keV)
LMC X-3
LMC X-1
4U 1543-475
XTE J1550-564
4U 1630-472
GRO J1655-40
GRS 1915+105
NGC 1313 X-1
NGC 1313 X-2
M81 X-9
Ho II X-1
NGC 4559 X-7
Ant. X-37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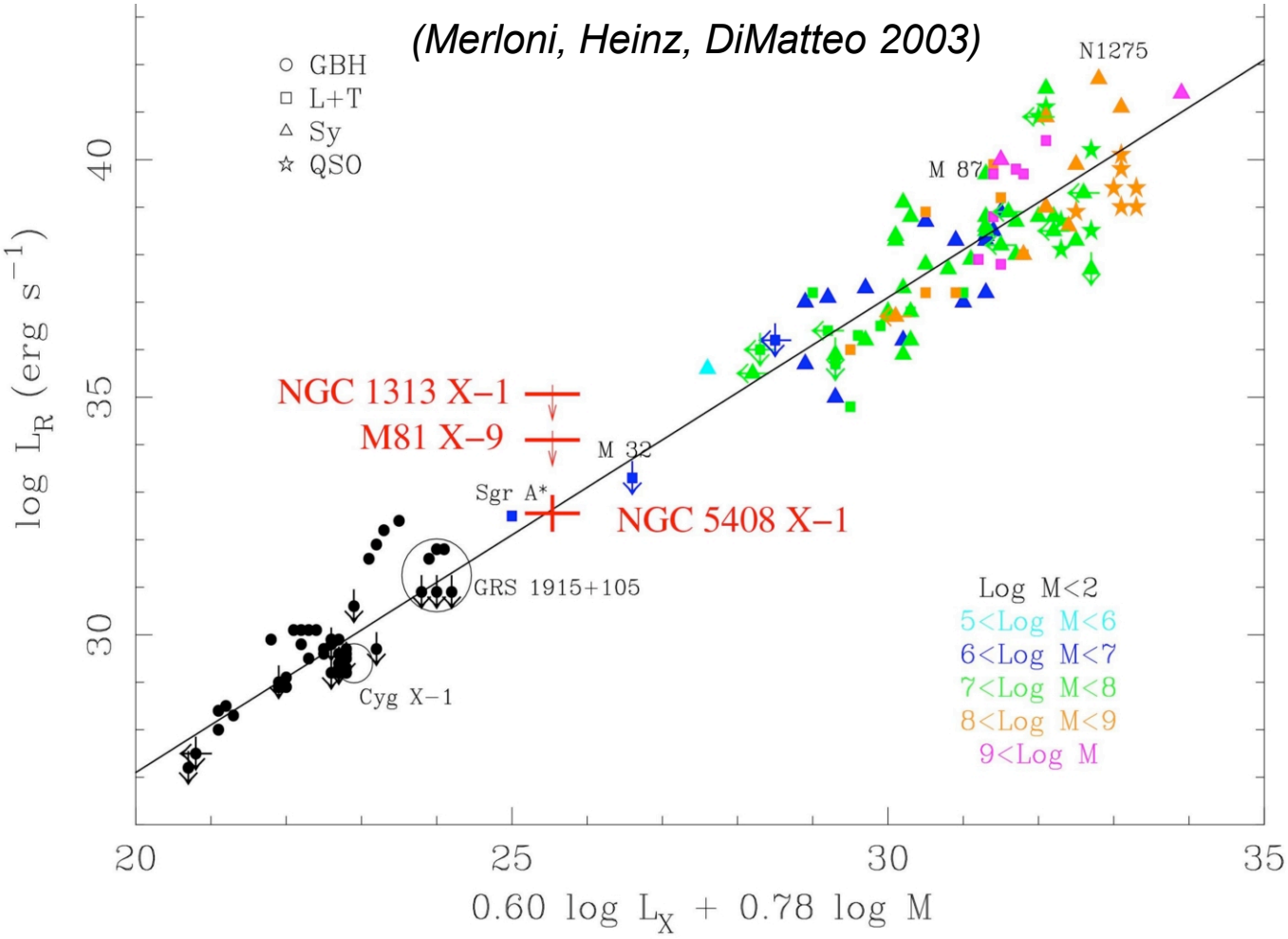
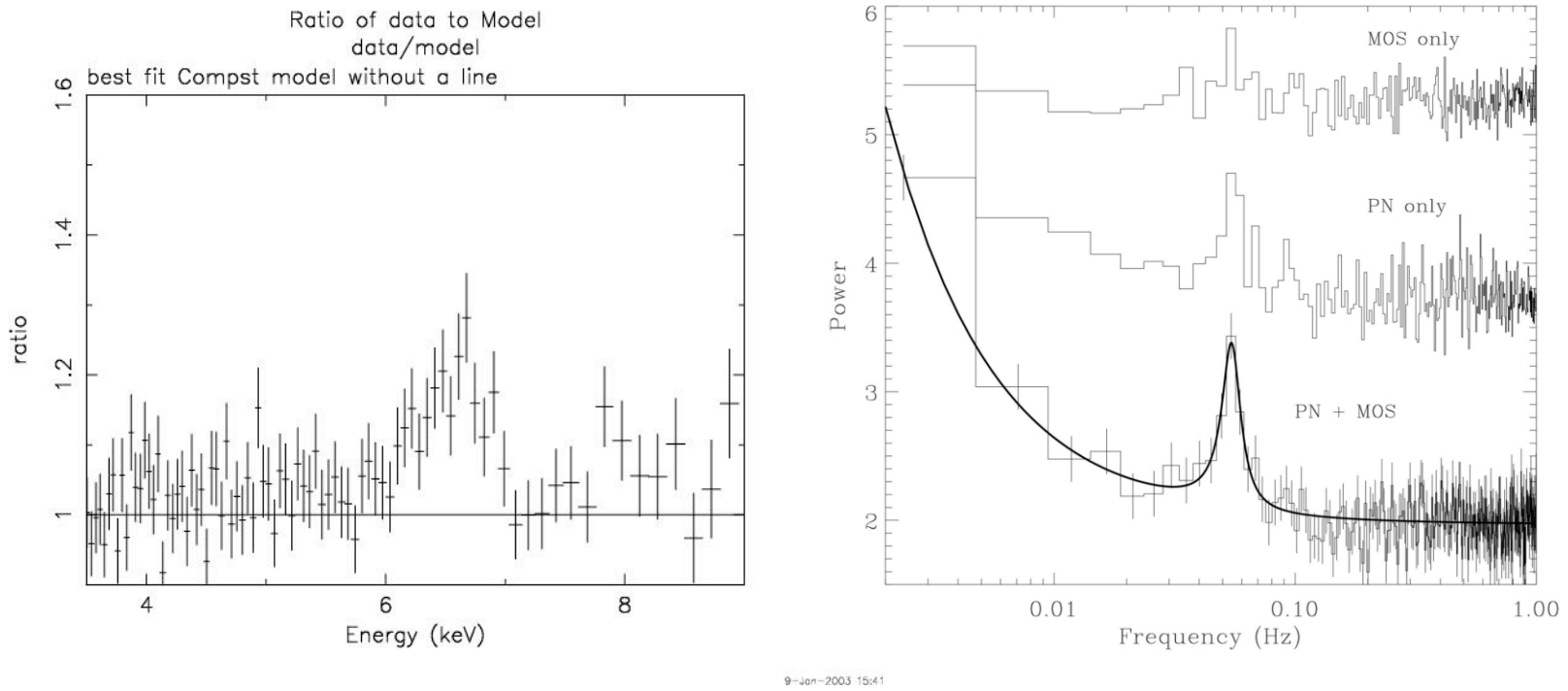
The Fundamental Plane:

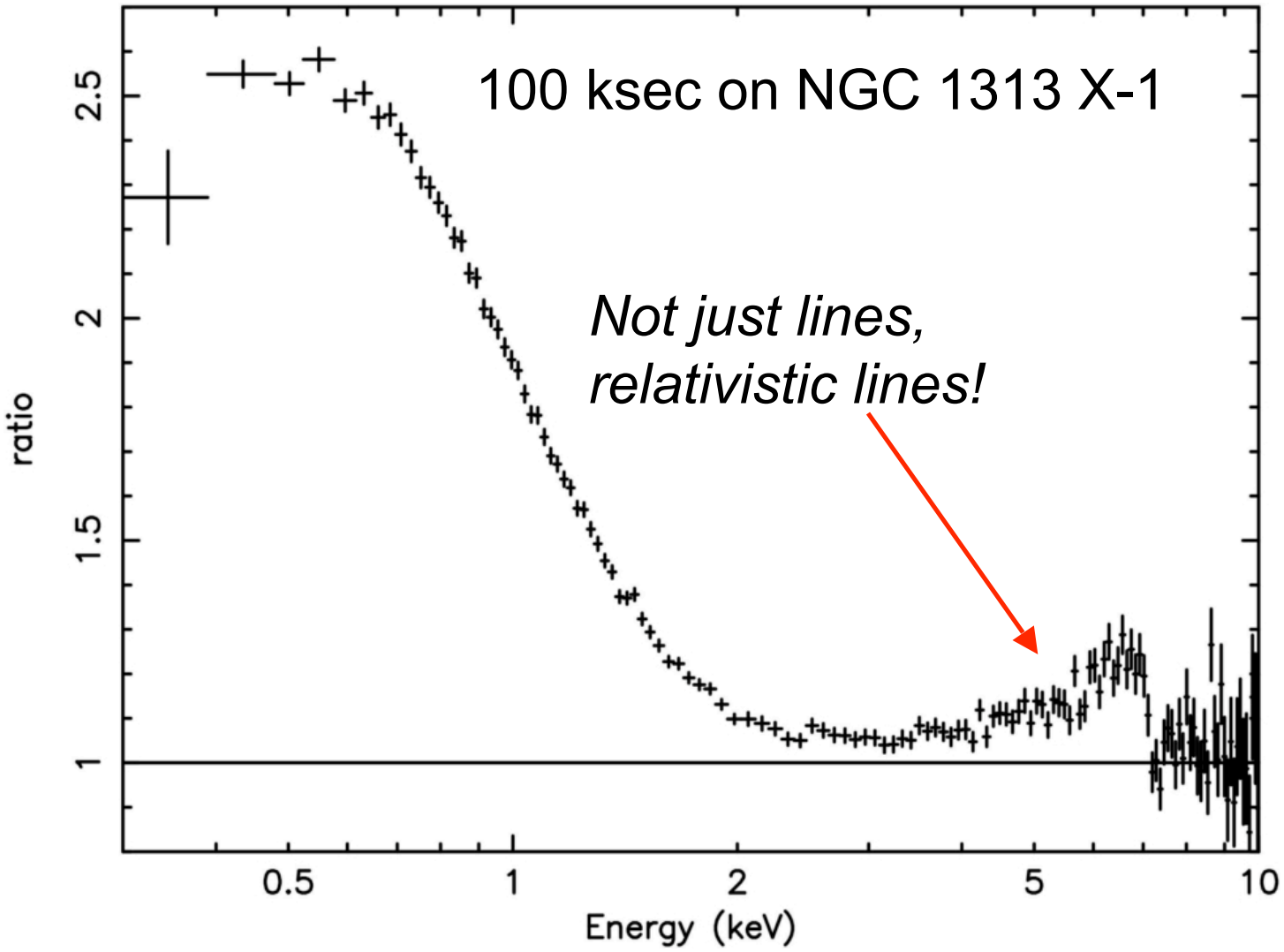


How to do better:

(Strohmayer & Muchotzky 2003)

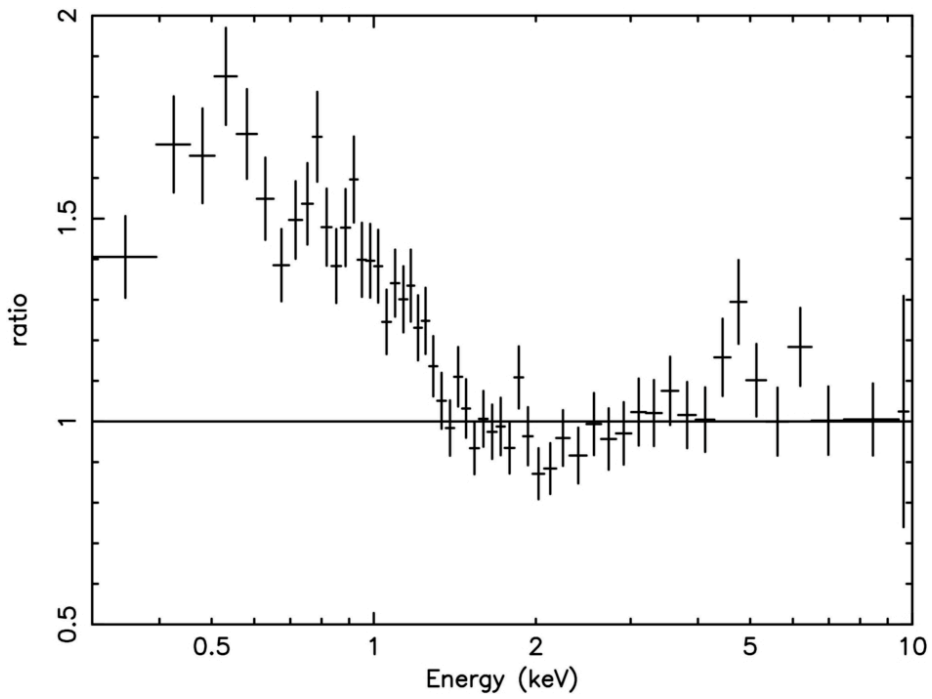


Doing better with Con-X:

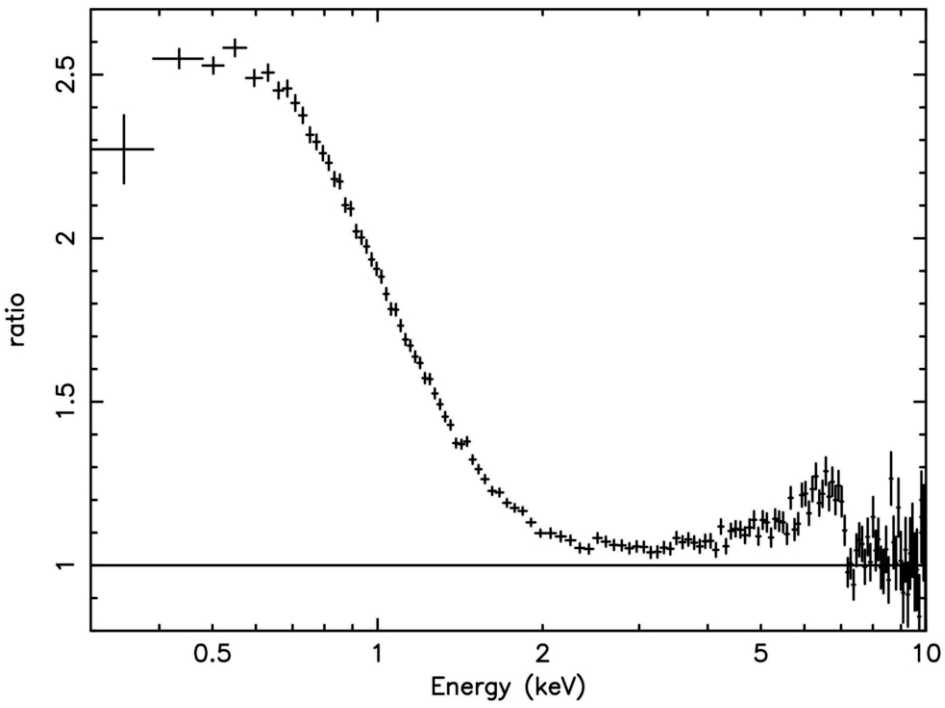


Side by side comparison:

40 ksec w/ XMM-Newton



100 ksec w/ Con-X



The QPO Equation (see vdK95):

$$N_{\_} = 0.5 * [s^2/(s+b)] * (rms)^2 * \sqrt{(T/\_\_)}$$

- For a QPO of a given q, S/N grows linearly with count rate (effective area) for b << s.

- With Con-X, then, QPO significances will be enhanced by R = A_con-x / A_xmm.

  R = 7-8 at 1-2 keV, 4-5 at 6 keV.

Relative Impact of Constellation-X:

AGN in which reverberation mapping will work:	6-8
Galactic black holes in which GR effects can be probed over a 10 year mission:	10-15
ULXs with some hint of IMBH nature, on which Con-X can be decisive with XMM-like resolution:	20-30

Disks, Fe K lines, QPOs in just 1/3, impact as large as for AGN, 10 Msun BHs.

1. NGC 1313 X-1
2. NGC 1313 X-2
3. NGC 4559 X-7
4. NGC 4559 X-10
5. NGC 3628 X-1
6. M81 X-9
7. M81 X-6
8. Holmberg II X-1
9. NGC 5408 X-1

10-13. Antennae sources

14. M101 SSS
15. NGC 5204 X-1

- IC 342 X-1
- IC 342 X-2
- Dwingeloo X-1
- NGC 6946 X-1
- NGC 2276 X-1
- Cartwheel X-1
- NGC 7714 X-1

… and there are others!

Summary

- Constellation-X can reveal IMBHs.
- Impact as great as for AGN, stellar-mass BHs.
- Tools which XMM can bring to bear:
  - Disk spectroscopy (& ruling-out any thin plasma)
  - Relativistic Line Spectroscopy
  - QPO timing studies